Stimulation of dorsal column in multiple sclerosis

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Summary and conclusions

The effect of stimulating the dorsal column in 19 selected patients with multiple sclerosis was studied in detail over two weeks. Before and during stimulation the patients were examined clinically; videotape recordings made of their movements; psychomotor performance tested; electrolaryngography performed; and urodynamic studies carried out. Improvement was seen in walking speed, power in certain muscle groups, chronic pain, and bladder function.

The motor improvement was thought to be related to the effects of high motivation and practice, and therefore to be of doubtful importance. The changes in bladder function were more convincing and justify further study.

Introduction

A chance observation by Cook¹ led to the suggestion that chronic stimulation of the posterior aspect of the spinal cord might improve some aspects of multiple sclerosis. Many reports have tended to be somewhat anecdotal or the trials lacking in measurable tests. In general, controlled trials of dorsal-column stimulation are not feasible because the patient is always aware that the apparatus is switched on. The present trial was completely open, but to compensate for this we made many observations and when possible recorded objective measurements.

Patients and methods of assessment

PATIENT SELECTION AND STIMULATION TECHNIQUE

We chose 19 patients with multiple sclerosis according to the following criteria: (1) they definitely had multiple sclerosis²; (2) they were under 55 years of age; (3) their condition had been clinically stable for at least six months before the trial; (4) they were reliable observers; and (5) they could walk 50 yards (46 m) with or without support.

We used the stimulation technique described by Cook and Weinstein.³ Two epidural electrodes 2-4 cm apart were positioned between T1 and T9. The stimulation was 33 Hz, with a pulse width of 200 μ s at the sensory threshold (typically 9-12 V). The patients were instructed to have the stimulator switched on continuously during the two-week assessment period. No physiotherapy was permitted.

CLINICAL EXAMINATION

Detailed neurological examination was performed at least once before and twice during the stimulation period. Particular attention was paid to muscle power (assessed by spring balance), two-point discrimination (at 14 sites on the limbs), and sense of joint position

(in eight digits). Clinical examination was also performed by an independent neurologist (Dr R E Kelly) before and during stimulation.

The patients were timed as they walked a set distance each day (typically 30 m). The average time taken in the week before treatment was compared with the mean in each week of stimulation. Any response relating to clinical examination was assessed on an arbitrary four-point scale—that is, no change; mild, moderate or pronounced change either advantageous or deleterious. Change was considered to have occurred if observations in both weeks of treatment had altered from the pretreatment assessment, in the same direction, by one or more points on the scale.

VIDEOTAPE RECORDINGS

Walking, turning, balance, general mobility, and co-ordination were filmed in all cases. The tapes, which were made before and after treatment, were reviewed and scored as above.

PSYCHOMOTOR TESTING

Psychomotor performance was assessed before and five and 10 days after implantation of the electrodes. Not all the patients could do every test, either because of their inability to carry out the task or because some of the tests were not included in the study from the beginning of the trial.

Balance was assessed by the patient's ability to stand with arms outstretched (eyes open, then shut) and on tiptoe for a timed period.

General mobility was evaluated by walking a set distance, and climbing up and down steps.

Control and co-ordination of arms and hands were measured by four tests—namely, tapping,⁴ "jump reaction time,"⁵ finger dexterity (using the PURDUE pegboard test),⁶ and hand steadiness (using the mazes from the Osteresky⁷ scale).

Control and co-ordination of legs were estimated by timing the speed of leg-crossing movements and flexion and extension movements at the knee.

URODYNAMIC STUDIES

Detailed measurements were made as follows in 14 patients before and typically on the eighth day of dorsal-column stimulation.

Residual urine was estimated twice before and twice during dorsal-column stimulation by catheterisation after a normal void. Mean values were compared.

Flow rate and pattern were recorded on several occasions by using a standard flowmeter (Mictograph, Disa), and voids of equivalent volume before and during stimulation were compared.

Filling and voiding cystometry—The subtracted detrusor pressure was recorded during intermittent medium-fill cystometry with 35% diodone at room temperature. Comparisons were made of the filling volume at which uninhibited contractions first occurred and the amplitude of the contractions. An improvement was classified as an increase by 100 ml or more in the filling volume at which the first uninhibited contraction exceeded 20 cm H₂O.

Videocystourethrography—Radiographic screening of the outflow tract was carried out during voiding by using a swing-arm image intensifier (Siremobile, Siemens). Voluntary contraction of the distal sphincter mechanism was classified as follows according to the patient's ability voluntarily to interrupt urine flow: normal, the patient could interrupt flow abruptly for at least five seconds; impaired, the patient could stop flow only momentarily or very slowly, or could only retard flow; and absent, the patient could not contract the sphincter at all during voiding.

External anal sphincter electromyography was carried out using bipolar needle electrodes.

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*Profiles of urethral pressure*⁸ were obtained and the response to alpha-adrenergic blockade with 10 mg intravenous phentolamine⁹ assessed.

Measurements made by patients—Each time the patients emptied their bladder they recorded the volume and the time taken. Such measurements were obtained daily for one week before and during the two weeks of dorsal-column stimulation. From several such values a mean time and volume were calculated for each day, from which the flow rate was derived (volume/time ml/s).

ELECTROLARYNGOGRAPHY

Electrolaryngography is based on the fact that electrical impedance across the larynx varies with the movement of the vocal cords.¹⁰ The impedance lessens when the folds are in contact, and laryngeal vibration may be recorded by placing electrodes externally on the neck. Recordings were made before and after stimulation of patients speaking a series of phonetically balanced sentences. Frequency distribution curves were plotted by a PDP12 computer, which was programmed to show the range of the frequency, the mode, and the pattern of vibration of the vocal cords.^{10 11} Interpretation of the results was based on subjective analysis of the frequency distribution curves and by listening to the speech recorded before and after stimulation. Normative data are not yet established, so patients acted as their own controls.

Results

CLINICAL EXAMINATION AND VIDEOTAPE RECORDINGS

Walking speed over a set distance increased in eight of the 19 patients—by 25% of the pretreatment value in four and by over 50% in four. Hip flexor strength improved in seven patients, and two increased their grip power. Mild improvement in two-point discrimination was seen in four patients. No change was detected in muscle tone, clonus, tendon reflexes, cerebellar function, vibration sense, sense of joint position, and cutaneous sensation.

The videotapes did no more than confirm the changes in walking speed. No qualitative improvement could be discovered.

Four patients suffered chronic central pain secondary to multiple sclerosis, and all reported some benefit.

PSYCHOMOTOR TESTS

The results were examined by one- or two-way analysis of variance. Non-parametric tests were used for the balance tests because many patients scored either zero or maximum points. Two-way analysis of variance was used for the tests of control and co-ordination of the arms and hands to test the effect of the session that was being assessed and which hand was used as well as the interaction of these two variables. Movements of the left and right legs were analysed separately because the presence of severe motor deficit in one leg alone prevented some subjects from performing the tests.

Results of only two tests reached significance—namely, tapping with the right hand ($p < 0.03$) and crossing the left leg over the right ($p < 0.05$). This was true only when sessions 1 and 3 were compared; differences between sessions 1 and 2 were not significant.

URODYNAMIC STUDIES

Symptomatic change—The 18 patients questioned before and after dorsal-column stimulation noted improvements in the following: urinary stream (13 patients), urgency (nine), hesitancy (seven), frequency (six), and incontinence (three). In two patients symptoms were unchanged. Some of these patient observations were objectively validated by a chart noting the volume of urine voided and the time taken. Any change in frequency could be accounted for by variation in fluid intake.

Estimations of residual urine varied according to the amount of urine passed. Suitable comparisons were made in 10 patients, five of whom showed a reduction in residual urine after dorsal-column stimulation varying from 57 to 163 ml.

Cystometry—Thirteen out of 14 patients studied had an unstable bladder. Only two showed a significant reduction in detrusor instability after stimulation.

Videocystourethrography—Six of the 14 subjects studied had

radiological evidence of outflow obstruction owing to dyssynergia of the detrusor sphincter, of whom one improved with dorsal-column stimulation. Seven of the 14 had impaired voluntary control over their sphincter mechanism and could not interrupt micturition on command; stimulation produced a noticeable improvement in two such patients.

External anal sphincter electromyography showed a change in only one out of six patients tested: this was a reduction in detrusor-sphincter dyssynergia, which was also observed on videocystourethrography.

Urethral pressure—Table I shows changes in the urethral-pressure profiles of seven patients in whom reliable results were obtained. Urethral pressure fell in five of the seven patients, and this related to

TABLE I—Urethral pressures before and after stimulation of dorsal column, and change in residual volume

Case No	Urethral pressure (cm H ₂ O)			Change in residual volume (ml)
	Before	After	% change	
1	112	81	-28	-75
2	61	35	-43	0
3	85	67	-21	-160
4	77	110	+43	+50
5	107	91	-15	-90
6	92	97	+5	+70
7	99	67	-32	-163

both symptomatic improvement and a reduction in residual urine. This change, however, did not quite reach significance (Student's two-tailed t test). In four patients profiles were repeated after alpha-adrenergic blockade with intravenous phentolamine. Total closure pressure fell with stimulation in three of these patients, and most of this reduction was found to be due to a lessening of alpha-adrenergic sympathetic activity (rather than somatic or parasympathetic) in the distal sphincter mechanism (table II).

TABLE II—Effect of alpha-adrenergic blockade (phentolamine test) in four patients (expressed as cm H₂O)

Case No	Change in total closure pressure with DCS	Sympathetic muscle component of change	Somatic and parasympathetic muscle component of change
1	-31	-20	-11
2	-26	-17	-9
3	-18	-13	-5
6	+7	+7	0

DCS = Dorsal-column stimulation.

Flow rate—Out of five patients assessed with a flowmeter, two showed a significant change in flow rate with stimulation.

Measurements made by patients were examined overall and individually in 13 cases. The serial changes in mean daily volume, time taken, and flow were pooled and assessed with Student's two-tailed t test. There were no significant changes in mean volumes for the group overall, but highly significant improvements in time and flow rate were observed ($p < 0.001$ in both instances). When results were assessed individually significant improvement ($p < 0.01$ or better) in flow was seen in 10 patients, of whom seven showed a significant reduction ($p < 0.01$ or better) in the speed of bladder emptying. Only four out of 10 patients showed a significant improvement in the mean volume voided.

ELECTROLARYNGOGRAPHY

Tracings made before and after stimulation were analysed in nine patients. The range of speech frequency and shape of the graph improved appreciably in one patient, implying that the vocal-cord vibration had become more regular. In one other patient with dysphonia speech frequency was slightly improved on the graph but not on simple listening tests. In five patients no change occurred, and in two deterioration was seen in the analysed tracing.

Discussion

The stimulation values and position of the electrodes in this study were those used by Cook¹ and are empirically derived. Whether different stimulation frequencies or electrode placements would be more beneficial has not yet been determined, but more gains in bladder function might possibly be achieved by stimulation over the lumbar enlargement. Although no major difficulties occurred in entering the epidural space, electrode manipulation was difficult and locating an area over the dura that would evoke leg tingling was often time consuming: such sensations are thought desirable for optimum effect of stimulation (A W Cook, personal communication). Electrode movement (or even extrusion) proved a recurrent problem, frequently necessitating readjustment, and improvement in electrode design is greatly needed.

Of the results of the clinical tests, the changes in walking speed are, at first sight, impressive. Evidence exists,^{1,2} however, that with repeated practice hip flexor power, grip, and two-point discrimination may improve. Many of our patients exercised themselves to the point of exhaustion, having to rest several minutes before being able to walk again. A similar interpretation might apply to the results of the psychomotor tests: leg crossing that uses hip flexors may be expected to improve with repeated trials.^{1,2} Moreover, a slightly better performance might be expected on the basis of greater familiarity with the test, improved confidence, and a higher level of motivation. None of the apparent improvement in psychomotor tests was enough to alter the general quality of the patients' daily existence.

By contrast, striking changes were seen in bladder function. On the basis of the patient's own measurements and flow tests, urinary stream (chiefly the speed of emptying) appeared to improve significantly. This could only occur if detrusor power increased or urethral resistance decreased. No increase in voiding pressures was observed, and thus the improvement was probably due to decreased urethral resistance. This is supported by the findings of reduced urethral pressure within the lumen of the distal sphincter mechanism. Only two patients showed a reduction in detrusor instability, but this occurred without any of the side effects so common with the drugs prescribed for this condition.

It is too early to say whether stimulation of the dorsal column will have a worth-while clinical role in the future. In theory various antispastic drugs could produce similar results but often at the expense of side effects, whereas no such unwanted actions were reported by any of our patients, a few of whom had already tried all standard treatment for their urinary symptoms without success. Confirmation that stimulation of the dorsal column reduces spasticity of the distal sphincter mechanism might be considerably important, because in general drug treatment is ineffective and dividing the external sphincter carries its own morbidity and a risk of increased incontinence.

The laryngographic study was carried out as a result of the suggestion that clarity of speech may be improved with dorsal-column stimulation (A W Cook, personal communication). Stimulating the thoracic cord might possibly have some effect on the function of the respiratory muscles or on the brain-stem centres concerned with articulation and phonation, but we cannot at present draw any firm conclusion on this.

Our data justify conclusions of guarded optimism. The improvement in walking speed and power in certain muscle groups could readily be achieved by intensive physiotherapy. The changes in bladder function are convincing, and it is in this area that future research should be carried out.

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References

- 1 Cook AW. Electrical stimulation in multiple sclerosis. *Hosp Pract* 1976; 2:51-8.
- 2 Schumacher GA, Beebe G, Kibler RF, *et al.* Problems of experimental trials of therapy in multiple sclerosis. *Ann NY Acad Sci* 1965; 122: 552-68.
- 3 Cook AW, Weinstein SP. Chronic dorsal column stimulation in multiple sclerosis. *NY State J Med* 1973; 73:2868-72.
- 4 Wyke MA. Influence of direction on the rapidity of bilateral arm movements. *Neuropsychologia* 1969; 7:189-93.
- 5 Fleishman EA. Dimensional analysis of movement reactions. *J Exp Psychol* 1958; 55:438-53.
- 6 Science Research Association. *Examiner's manual for the Purdue peg board*. Chicago: Science Research Association, 1948.
- 7 Doll EA, ed. *Osteresky tests of motor proficiency*. Minnesota: American Guidance, 1946.
- 8 Brown M, Wickham JEA. The urethral pressure profile. *Br J Urol* 1969; 41:211-7.
- 9 Whitfield HN, Doyle PT, Mayo ME, Poopalasingham N. Effect of adrenergic blocking drugs in outflow resistance. *Br J Urol* 1975; 47: 823-7.
- 10 Fourcin AJ, Abberton E. The laryngograph and the voicscope in speech therapy. In: *XVI International congress of logopedics and phoniatrics*. Basle: S Karger, 1976:116-22.
- 11 Neil WF, Wechsler E, Robinson JMP. Electrolaryngography in laryngeal disorders. *Clin Otolaryngol* 1977; 2:33-40.
- 12 Tourtellotte WW, Haerer AF, Simpson JF, Kuzma JW, Sikorski J. Quantitative clinical neurological testing I. *Ann NY Acad Sci* 1965; 122: 480-505.

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ONE HUNDRED YEARS AGO The published reports of the trial of the convict Wingfield, who was sentenced to death by Mr Justice Grove at the Central Criminal Court on the 4th instant, for the wilful murder of his wife, suggest grave doubts whether he was of sound mind when he committed the act, and whether he is not now labouring under disease of the brain. The convict, who has a sister confined in a lunatic asylum, and who is described as a person of very violent disposition, easily roused, was examined by Mr Ring, a surgeon at Kilburn, a year ago, when he was in custody on a charge of breaking the windows of his house, and was then thought to be irresponsible for his actions. He was in a very excited state, and it was deemed desirable that he should be placed under observation. The murder for which he has been condemned was committed in the public street in broad daylight, when he stabbed his wife fourteen times in the head and body, saying to her as he did so, "You know I love you, my girl; I don't like to see you in misery." Having completed the butchery, he knelt down and kissed her. The motive of the crime suggested was jealousy, revealed in the exclamations of the convict,

who, when stabbing his wife, said to her, "That is for going and dancing at the Metropolitan Music Hall"; and who also addressed the bystanders, and said, "She went to the Metropolitan Music Hall, and left my poor children at home starving." But it does not appear to have been proved that his wife had actually done as he said she had, or that he had any reasonable grounds for believing the statements which he made respecting her. The knife with which he committed the murder was won in a lottery, but he intimated that he had got it from the Sisters of Mercy to do for his wife. During the summing-up of the judge, the prisoner had to be attended to by Mr Gibson, the Surgeon of Newgate, and Mr Carpenter of Clerkenwell Prison, on account of a species of fit, "occasioned," says the legal reporter, "by remorse." A faint might have been easily explicable considering the trying circumstances in which the prisoner was placed; but a species of fit occasioned by remorse is suggestive of epilepsy, which would, of course, account for paroxysms of fury, with violence, delusions, and confused statements. The case evidently demands a thorough investigation by skilled persons. (*British Medical Journal*, 1880.)